PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

Improvements relating to Electrodialytic Cells

We, THE PERMUTIT COMPANY LIMITED, a British Company, of Permutit House, Gunnersbury Avenue, London, W.4, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

It is known to remove dissolved salts from liquids by passing the liquid in question through every alternate compartment of a multi-compartment electrodialytic cell in which the compartments are separated from one another by ion-selective membranes.

Processes of this kind are very suitable for the demineralisation of water by the passage of the water through compartments each bounded on one side by a cation-selective membrane and on the other side by an anion-selective membrane, while a second electrolyte (usually also water) flows through the remaining compartments to receive the ions transported through the membranes by the electric current flowing through the cell. When the total amount of dissolved solids in the water under treatment falls to about 500 ppm or is no more than this initially, it is necessary to apply so high a voltage to the cell that the process ceases to be economic.

It is also known to fill the compartments with granular ion-exchange material. The reason for doing this is to increase the electrical conductivity in the compartments and so to reduce the overall electrical resistance when the concentration of ionised dissolved solids in the liquid is low. Consequently water containing less than 500 ppm total dissolved solids can be economically treated

The granular ion-exchange materials most widely used at the present time are resin beads of from 0.5 to 1 mm in diameter. Now the use of granules such as resin beads has several disadvantages. First, it is difficult to ensure that they are initially distributed evenly within a compartment and that the several compartments through which the liquid to be treated usually flows in parallel streams are evenly packed. If one compartment contains more granules than another, less liquid will flow through it than through the other. Next it is difficult to keep the granules in place in a compartment. At the best the packed mass of granules becomes displaced by the liquid, with the result that channelling with its attendant drawbacks occurs. It may even happen that some of the granules are swept out of the compartment to lodge in and clog the passage through which the liquid flows after leaving the compartment.

Again, the assembly of a cell containing granules is very tedious and it is difficult to prevent the granules from lodging between the surfaces which should mate to seal each compartment from the next. Further, where the packed mass of granules touches the membrane faces the geometry of the mass is different from that in the remainder of the mass, and more liquid tends to flow along the walls than through the bulk of the mass. This uneven flow is undesirable. Finally, if the compartments are packed with granules the total resistance to the flow of the liquid is increased and the cost of pumping the liquid through the cell is high.

According to this invention we use not beads but sheets of material having ion-exchange properties which may be pieces of ion-selective membrane. The sheets may be put in all the compartments but in general it is enough to put them in those compartments through which the liquid under treatment flows and in which the electrolyte concentration is or becomes low.

The sheets may all have ion-exchange properties of only one kind, but if it is desired to have both cation-exchange and anion-

exchange material in a single compartment, sheets of both kinds of material may be put in the compartment or the sheets used may contain both cation-exchange and anion-exchange groups.

The sheets may advantageously be of substantially the same length and width as the membrane faces within the compartments. As is the case with beads, the sheets must allow liquid to flow through the compartments. To this end they may be flat and perforated, corrugated with or without perforations, or embossed with a pattern; they may be of gauze or woven fabric, or they may be formed of granules lightly cemented together, so as to be liquid-permeable. Alternatively the sheets may be smaller than the compartment, for example they may be pieces cut from larger sheets. Such cut pieces may be of any shape, either regular or irregular.

In any case the sheets are parallel or substantially parallel to the membrane faces, since a compartment is normally very narrow and a sheet can be inserted in it with the major faces of the sheet parallel to the membrane faces. Various arrangements can be used to give the required flow. For example, the sheets may be corrugated with the corrugations parallel to the direction of flow or may be corrugated and perforated with the corrugations lying at any angle, or be flat and perforated in such a way that the perforations in one sheet are staggered relative to those in the next sheet.

The sheets may consist of pieces of gauze or woven fabric carrying ion-exchange groups. For instance, they may be cotton fabric or gauze chemically treated (and so rendered more or less rigid) to introduce ion-exchange groups. Again, they may be pieces of a gauze of a resin polymer, e.g. polyvinyl chloride, the strands of the gauze being coated with an ion-exchange resin or with particles of such a resin embedded in a matrix. Such sheets are naturally perforated and it is sufficient to put them in face contact with one another in the compartment until this is full of the perforated sheets. If the weave is very close, it may be necessary to make perforations in a fabric. Similarly, if a coating on a gauze blocks the interstices, perforations may be made in the gauze.

Yet again, the sheets may be embossed so as to resemble parallel rods joined to one another by thinner webs.

The dimensions of a typical compartment in a small cell may be 12 inches × 12 inches × 50 thousandths of an inch. Such a compartment may contain no more than two sheets if these are perforated sheets each 12 inches square and 25 thousandths of an inch thick; such sheets may both be perforated with holes, say, $\frac{1}{4}$ inch diameter in a close regular pattern but offset from one another in the two sheets. One such piece may have cation-exchange properties and the other anion-exchange properties.

Again pieces in the form of discs cut from a large sheet may be $\frac{1}{2}$ inch in diameter and 25 thousandths of an inch thick, and may be arranged either so that the one layer is all of the one type and the other layer all of the other type or each type may appear in both layers.

When fabric or gauze is used it may be, say, 5 thousandths of an inch thick, layers being laid in face contact with one another to fill the compartment. The layers may alternate in their ion-exchange properties.

WHAT WE CLAIM IS:—

1. A multi-compartment electrodialytic cell in which the compartments are separated from one another by ion-selective membranes, and material having ion-exchange properties is provided in some or all of the compartments to increase the electrical conductivity therein while allowing liquid to flow through the compartments, in which the material is in sheet form.

2. A cell according to Claim 1 in which the sheets are of substantially the same length and width as the membrane faces within the compartments.

3. A cell according to Claim 1 or Claim 2 in which the compartments contain at least one sheet with cation-exchange properties and another with anion-exchange properties.

4. A cell according to any one of the preceding claims in which the sheets are perforated.

5. A cell according to any one of the preceding claims in which the sheets are corrugated.

6. A cell according to any one of the preceding claims in which the sheets are of fabric or gauze carrying ion-exchange groups.

7. A process for the demineralisation of water by passage of water through alternate compartments bounded on one side by a cation-selective membrane and on the other side by an anion-selective membrane in a multi-compartment electrodialytic cell while a second electrolyte flows through the remaining compartments, the compartments through which the water to be demineralised flows containing ion-exchange material to increase the electrical conductivity therein while allowing the water to flow through the compartments, in which the material is in sheet form.

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PROVISIONAL SPECIFICATION

Improvements relating to Electrodialytic Processes

We, THE PERMUTIT COMPANY LIMITED, a British Company, of Permutit House, Gunnersbury Avenue, London, W.4, do hereby declare this invention to be described in the following statement:—

It is known to remove dissolved salts from liquids by passing the liquid in question through every alternate compartment of a multi-compartment electrodialytic cell in which the compartments are separated from one another by ion-selective membranes.

Processes of this kind are very suitable for the demineralisation of water, but when the total amount of dissolved solids falls to about 500 ppm. or is no more than this initially, it is necessary to apply so high a voltage to the cell that the process ceases to be economic.

It is also known to fill the compartments with granular ion-exchange material. The advantage of doing this is that the overall electrical resistance is reduced when the concentration of ionised dissolved solids in the liquid is low, and consequently water containing less than 500 ppm. total dissolved solids can be economically treated.

The granular ion-exchange materials most widely used at the present time are resin beads of from 1 to 2 mm in diameter. Now the use of granules such as resin beads has several disadvantages. First, it is difficult to ensure that they are initially distributed evenly within a compartment and that the several compartments through which the liquid to be treated usually flows in parallel streams are evenly packed. If one compartment contains more granules than another, the streams flowing through them will differ. Next it is difficult to keep the granules in place in a compartment. At the best the packed mass of granules becomes displaced by the liquid, with the result that channelling with its attendant drawbacks occurs. It may even happen that some of the granules are swept out of the compartment to lodge in and clog the passage through which the liquid flows after leaving the compartment.

Again, the assembly of a cell containing granules is very tedious and it is difficult to prevent the granules from lodging between the surfaces which should mate to seal each compartment from the next. Further, where the packed mass of granules touches the membrane faces the geometry of the mass is different from that in the remainder of the mass, and more liquid tends to flow along the walls than through the bulk of the mass. This uneven flow is undesirable. Finally, if the compartments are packed with granules the total resistance to the flow of the liquid is increased and the cost of pumping the liquid through the cell is high.

According to this invention we put an ion-exchange material into a cell in the form of pieces having at least one dimension, and preferably two dimensions, distinctly larger than the usual beads. We are able to use fewer pieces, and in the preferred forms far fewer pieces, than the number of granules required hitherto in a compartment. In fact at least it is possible by means of the invention to avoid all the disadvantages described above.

The pieces may all have ion-exchange properties of only one kind, but if it is desired to have both cation-exchange and anion-exchange material in a single compartment, pieces of both kinds of material may be put in the compartment or the pieces used may contain both cation-exchange and anion-exchange groups.

The pieces of ion-exchange material used according to this invention may be elongated in one dimension, i.e. be of a generally rod like form, or in two dimensions, i.e. in the form of sheet. Usually one or more major dimensions in each piece is or are substantially greater than a minor dimension. Each major dimension is preferably greater than the thickness of the compartment to be filled, and in general the pieces will have at least one major dimension of at least half an inch.

The pieces may themselves be composite, being composed for example of short lengths of extruded rod joined together. Again, a composite piece may consist of granules lightly cemented together, e.g. into a sheet, so as to be liquid-permeable. A cutting may be made from a composite sheet and used as a piece.

Advantageously pieces of ion-exchange material may be sheets of a size sufficient to cover the whole of a membrane face within a compartment. These sheets may be flat, corrugated, or embossed with a pattern; they may be of gauze or woven fabric, or they may be formed of cemented granular material as mentioned above. Alternatively the sheets may be smaller than the compartment, for example they may be pieces cut from larger sheets. Such cut pieces may be of any shape, either regular or irregular.

In order to allow liquid to flow through a compartment the piece must not completely fill the compartment. Various arrangements can be used to give the required flow. For example, the pieces may be corrugated sheet with the corrugations parallel to the direction of flow or may be sheet corrugated and perforated with the corrugations lying at any angle or be flat sheets perforated in such a way that the perforations in one sheet are staggered relative to those in the next sheet.

Pieces of gauze or woven fabric used accord-

ing to the invention may be made, for example, by chemically treating cotton fabric or gauze to introduce ion-exchange groups. The products are naturally perforated and it is sufficient to lay these one on top of the other until the compartment is full. If the weave is very close, it may be necessary to make perforations in a fabric.

Again, the pieces may be bundles of ion-exchange material in fibre or rod form. These can be packed in parallel bundles with their axes parallel to the direction of flow. The rods or fibres may be of a length equal to that of the compartment or be shorter.

Yet again, the pieces may be sheets or parts of sheets embossed so as to form parallel rods joined to one another by thinner webs.

The dimensions of a typical compartment in a small cell may be 12 inches × 12 inches × 50 thousandths of an inch. Examples of pieces in such a compartment will now be given. For instance, such a compartment may contain no more than two pieces if these are perforated sheets each 12 inches square and 25 thousandths of an inch thick; such sheets may both be perforated with holes, say, ¼" diameter in a close regular pattern but offset from one another in the two sheets. One such piece may have cation-exchange properties and the other anion-exchange properties.

Again pieces in the form of discs cut from a large sheet may be ½ inch in diameter and 25 thousandths of an inch thick, and may be arranged either so that the one layer is all of the one type and the other layer all of the other type or each type may appear in both layers.

When fabric or gauze is used it may be, say, 5 thousandths of an inch thick, layers being laid one on top of the other to fill the compartment. The layers may alternate in their ion-exchange properties.

If bundles of rods are used they may be 12 inches long to fill a 12 inch compartment, or they may be shorter and laid end to end to make up the length of the compartment. They should be arranged so that the liquid flow is along their length.

Again, rods each, say, 50 thousandths of an inch in diameter may be laid in a single layer to occupy the whole thickness of the compartment, and may be alternately cation-selective and anion-selective.

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